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ABSTRACT

Ten case studies of collaborative arrangements between postsecondary vocational education institutions and companies manufacturing or using advanced technologies are reported in this document. The intention is to explore exemplary approaches to planning, developing, and implementing training programs for technicians in rapidly changing high-technology areas to meet emerging skill needs for American businesses and industries seeking to improve productivity. The case studies examine training programs in advanced computer applications, microelectronics, medical electronics, advanced manufacturing, and advanced office technologies. The contributions of both the schools and the participating companies are examined, including their collaborations in program planning and development activities; in finding funding, equipment, and facilities for the programs; in recruiting or upgrading skills of instructional staff; in devising or revising curricula; in obtaining state approval of new programs; and in effecting technology transfer for schools' and industries' mutual benefit. Recommendations are offered to leaders in education, business, and industry for fostering the growth of high technology and developing appropriate technician-level training programs. (KC)

Research & Development Series No. 229

Preparing for High Technology:
Programs That Work

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1982

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FOREWORD

This report presents various approaches used by a sample of postsecondary education institutions to meet training needs for skilled technicians in high-technology areas. Five broad areas of high technologies (microelectronics, advanced manufacturing, medical electronics, advanced office machines and procedures, and advanced computer applications) were used to guide selection of ten postsecondary institutions and local businesses/industries involved in the planning, development, support, and/or implementation of high-technology training programs. Findings are reported as case studies, and discussions and recommendations for postsecondary educators and industrial or business planners are offered.

The project staff is indebted to staff of the postsecondary institutions and companies who participated in the case studies. Postsecondary institutions visited were: North Lake Community College, Irving, TX; Durham Technical College, Durham, NC; Macomb County Community College, Warren, MI; Cincinnati Technical College, Cincinnati, OH; Tri-County Technical College, Pendleton, SC; Milwaukee Area Technical College, Milwaukee, WI; Franklin Institute, Boston, MA; Piedmont Technical College, Piedmont, SC; and Portland Community College, Portland, OR. Business and industry participants include Texas Instruments, Irving, TX; Digital Equipment Corporation, Boston, MA; Cincinnati Milacron, Cincinnati, OH; Tufts-New England Medical Center, Boston, MA; Portland Port Authority, Portland, OR; Employers Benefit Insurance Company, Portland, OR; and Allen Bradley Company, Milwaukee, WI.

The project staff would like to express appreciation also to staff at a number of sites visited that are not reported here, but which contributed substantially to our understanding of the external and structural barriers as well as the solutions used in developing and operating high-technology programs. They include the personnel at National Semiconductor, West Jordan, UT; Dow Chemical, Freeport, TX; Interstate Brick Company and Utah Power and Light, Salt Lake City, UT; Monsanto Corporation, Texas City, TX; Signetics, Provo, UT; Emmanuel Hospital, Portland, OR; and the A.O. Smith Company, Milwaukee, WI. The college sites included College of the Mainland, Texas City, TX; Brazoport Community College, Lake Jackson, TX; Wentworth Institute, Bunker Hill Community College, and Minute-Man Vocational-Technical School, Boston, MA; Utah Basin Area Vocational School, Roosevelt, UT; Utah Technical College at Provo, UT; Utah Technical College at Salt Lake City, UT; Linn-Benton Community College, Albany, OR; Lane Community College, Eugene, OR; Midlands Technical College, Columbia, SC; Greenville Technical College, Greenville, SC; Central Caroline Technical College, Sanford, NC; Catawba Valley Technical College, Hickory, NC; Industrial Engineering Department, North Carolina State University, Raleigh, NC; and Georgia Institute of Technology, Atlanta, GA. Other sites visited were: The State Board for Technical and Comprehensive Education, Columbia, SC; the Microelectronics Research Center and the North Carolina State Department of Community and Technical Colleges, Raleigh, NC.

Molly Orth, of the National Center, Dr. Carol Fought, of the Columbus Technical Institute, and Newton Brokaw, of the Columbus Industrial Association, served as reviewers of this report, and we thank them for their valuable help in refining the document. Editorial review was provided under the direction of Janet Kiplinger of the National Center.

EXECUTIVE SUMMARY

Ten case studies of collaborative arrangements between postsecondary vocational education institutions and companies manufacturing or using advanced technologies are reported in this document. The intention is to explore exemplary approaches to planning, developing, and implementing training programs for technicians in rapidly changing high-technology areas to meet emerging skill needs for American businesses and industries seeking to improve productivity. The case studies examine training programs in advanced computer applications, microelectronics, medical electronics, advanced manufacturing, and advanced office technologies.

The contributions of both the schools and the participating companies are examined, including their collaborations in program planning and development activities; in finding funding, equipment, and facilities for the programs; in recruiting or upgrading skills of instructional staff; in devising or revising curricula; in obtaining state approval of new programs; and in effecting technology transfer for their mutual benefit. Recommendations are offered to leaders in education, business, and industry for fostering the growth of high technology and developing appropriate technician-level training programs. Included among these topics are suggestions for:

- Establishing cooperative linkages of postsecondary schools with other technical and community colleges, local business and industry, state and local economic development agencies, employer associations, and professional societies
- Maintaining awareness of technological changes and evaluating need for new technology program development policies
- Expanding the membership and roles of program advisory committees
- Redefining resource development for new programs including funding policies, ways for gaining access to expensive or exclusive equipment and facilities, and instructional staffing

INTRODUCTION

The Problem

American businesses and industries currently are in a major technological transition period not unlike the Industrial Revolution in scope and impact. This transition is being driven mainly by dramatic advances in computer applications, microelectronics, and automated machinery and processes. Some industries (e.g., steel and automobile manufacturers) have failed to keep pace with the rapid technological changes. They, and many other industries that have been slow to adopt or adapt newer technologies, are finding themselves in a squeeze between foreign competition and rising costs of energy, labor, and materials.

Although prospects for surviving this transition period are bleak for some industrial sectors, other industries (or companies within those industries) are successfully adapting new technologies, improving productivity (some dramatically), utilizing human resources more effectively, and regaining or increasing their leadership in the world markets. The improvements they have achieved have often required substantial changes in work settings, equipment and processes, job performance requirements, and occupational demands and opportunities. To the extent that adopting or adapting new technologies is part of the competitive edge for any company, there are substantial implications for the utilization of both hardware and human resources, and for the educational institutions that prepare people to work in such companies.

If education (and particularly postsecondary vocational education) is to play a role in aiding American businesses and industries to maintain or regain their technological leadership and improve their productivity, then more than conventional wisdom and traditional approaches will be needed to formulate educational policies and plan training programs. Innovative approaches and strategies are needed to facilitate vocational programs' responsiveness to occupational changes. Even more important, postsecondary programs will need to become more directly involved in helping to transfer technological innovations across and into industries and businesses. In effect, ways must be found to encourage vocational educators to expand beyond their current reactive roles and to become more aggressive in promoting the use of new technology in cooperation with the business and industry community.

This report examines how some postsecondary colleges have managed to respond in a timely and effective manner to the challenges of industries' high-technology training needs. Schools' problems and successes in acquiring necessary material and human resources for program development and implementation are documented, and their involvement with local businesses and industries in the transfer of new technologies is described.

Purpose and Methods of the Project

The Technology Adaptation Project was an initial investigation of successful approaches being used in postsecondary institutions to assist business and industry in adopting or adapting advanced technology innovations as a means for improving productivity and aiding economic growth.

The first step in the research was to identify five high-technology areas as the focus for the study of successful approaches. Selection of the technological areas was based on reviews of scientific journals, American and foreign research reports and books, and newspapers and news magazines. These sources were scanned for information on areas such as technological development, economic development, productivity, and human resources development. Based on these reviews, five general categories of advanced technologies were selected:

- Advanced manufacturing technologies (including robots)
- Business office technologies (including word processors)
- Health and biological technologies
- Microelectronics technologies
- Computer applications technologies

The next step was to compile a list of candidate schools and companies from which final selection of sites would be made. Companies selected are those that use or produce the new technologies in the form of new equipment, processes, or materials. They are leaders in each of the technological categories selected and have established collaborative arrangements with postsecondary education institutions to help the schools develop new training courses or programs vital to the industries involved.

A list of candidate schools linked with businesses and industries in the five technology areas was compiled from the following sources:

- Recommendations from the American Association of Community and Junior Colleges (AACJC)
- Recommendations from Postsecondary Alliance members working at the National Center for Research in Vocational Education
- Telephone calls to corporate headquarters of companies using or manufacturing high-technology products
- Reviews of research reports and popular literature

Selection of industry/school sites was made by reviewing the two lists of candidate companies and schools to identify the following:

- Sites that appeared on both lists
- Sites that offered unique characteristics in program development and industry/school linkages (e.g., the only school offering a particular advanced technology program or sequence of courses, unique arrangements for use of equipment or instructional staff, postsecondary thrusts in advanced technology transfer, and so forth)
- Geographical clustering of sites to minimize time and cost factors of travel

Advanced-technology programs were selected to represent a variety of types and stages of program development, from a rapid start-up, industry-funded program in precision optics to a full two-year associate degree program in laser/optics that resulted from long-term planning. Selected programs reflected a range of problems encountered in planning, developing, and implementing an advanced-technology training program, and offered an array of resourceful solutions to these problems. Program selection was also based on the nature of collaborations established with local companies. The nature of the collaborations, including key actors and anticipated outcomes, was explored in detail at each site.

The presentation and discussion of site visit findings and study recommendations for improving program development appear in the following two sections. The first section contains descriptions of five case studies of companies and postsecondary schools involved in collaborative efforts to initiate programs or course sequences in high technology. The second section presents case studies that focus on details of program planning and development activities employed by five postsecondary schools.

PART I

Cooperative Industry-Education Initiatives

ADVANCED COMPUTER APPLICATIONS

ALLEN BRADLEY COMPANY

and

MILWAUKEE AREA TECHNICAL COLLEGE (MATC)

Focus: Development of a core curriculum for computer graphics technicians that is being integrated into eleven occupational areas

Allen Bradley Company, Milwaukee

The Allen Bradley Company was founded in 1909 in Milwaukee, Wisconsin as a family venture. Its early products consisted of speed controllers for electric motors and resistors for the electronics market. Currently the company manufactures hundreds of products in the following three groups:

Industrial controls – a wide range of devices that control and protect electric motors, including motor starters, programmable controllers, numerical controls, and adjustable speed/torque drives

Electronic components – ranging from fixed and variable resistors to complex networks for application in calculators, computers, instruments, machine tool controls, and communications equipment

Magnetic materials – such as ferrite cores and ceramic permanent magents for such products as machine tools, computers, automobiles, outboard motors, and electric shavers

The company has over ten thousand employees with major plants overseas as well as in North and South America. In addition to its manufacturing facilities, Allen Bradley has research and testing laboratories for product improvement, and has training centers for distribution personnel, customer service personnel, field sales specialists, and other company staff. The training centers provide career training programs such as management development, and conduct informational seminars on product development and changing technology.

Computer graphics is relatively new to the product design field, and Allen Bradley has been investigating this technology in its developmental engineering section, with the goal of increasing productivity. Allen Bradley's expectations are based largely on the fact that computer graphics software allows translation of a production drawing into specifications for tool design as well as tooling illustrations, which are then used to make tools for manufacture of the product. The availability of the production drawing as a computer graphic offers other advantages, such as product modification and cost estimations during the many stages of product design and manufacture. As one Allen Bradley product designer reported, "We can draw entire pictures on the keyboards that we had to draw before with our hands. And that can really increase productivity."

There is currently a need at Allen Bradley for postsecondary school graduates with computer graphics knowledge and skills. The greatest need is for graduates who have training in related subjects such as machine design or electrical technology. These employees need skills and knowledge above and beyond understanding basic computer interactive functions; they must also be capable of carrying out design responsibilities.

To handle its computerized design and production needs, Allen Bradley is working on its own computer graphics training program. Such a program will eventually be offered to employees along with the company's other in-house training programs. However, this program would apply specifically to Allen Bradley's system of product design. Technicians with strong backgrounds in basic product design and manufacturing, supplemented by computer graphics courses, will still be recruited from postsecondary technical schools by Allen Bradley.

In its attempts to provide and maintain strong linkages with local postsecondary educational systems, the company recently initiated a skill-work program with Milwaukee Area Technical College (MATC). Two MATC instructors spent the summer of 1981 working at Allen Bradley to gain experience and to learn about recent technological advances in their fields. Transportation for selected instructors from MATC was provided by Allen Bradley to attend an industrial show on the current state-of-the-art equipment and materials in computer graphics. This company, and others in the Milwaukee area, send experienced employees (such as engineers) to the MATC summer or evening program in computer graphics.

These important linkages between industry and school are planned to help participants keep pace with rapidly advancing technology that has great potential for cost reductions in product design and manufacture, with the added benefit of increased quality. The CAD (Computer-Aided Design) system is already a reality, as is CAM (Computer-Aided Manufacturing). The blending of these computerized processes into a continuous CAD/CAM system with a single database is at hand. Management staff at Allen Bradley feel that both school and industry are intimately involved in applying this expanding technology, and must cultivate mutual interest and enthusiasm to keep pace with it.

This theme has been translated by MATC into an organization of businesses and industries entitled Partners in Progress. Over fifteen companies (including Allen Bradley) and six educational institutions or professional groups belong to the partnership. The commitment of the partnership is to provide education and training in advanced technologies. Subscribing partners (i.e., those making a financial contribution) hold membership on the Advanced Technology Council, which is responsible for establishing priorities for funding advanced technological projects. Subscribing partners also have the opportunity to influence critical areas of worker development, such as computer graphics.

Milwaukee Area Technical College, Milwaukee

Milwaukee Area Technical College (MATC) is a four-campus network of postsecondary facilities serving a population base of 1.1 million people in a five-county area. The college offers sixty-five associate degree programs and eighty vocational certificate or diploma programs through twenty-three hundred day and evening courses, including related instruction for various apprenticeship programs. Its 1978-1979 enrollment was 68,863 part-time and full-time students. These students were served by almost two thousand part-time and full-time faculty and staff.

MATC was introduced to computer graphics when its faculty and staff became involved in a computer graphics training program at the General Electric Medical Systems Division. Subsequently, an advisory committee was formed to plan a computer graphics program. The committee concluded that emphasis should be on teaching well-developed basic occupational skills in all technical programs, with computer graphics courses added as a new tool to improve productivity.

Eleven occupational program areas were identified that require computer graphics skills. The programs are grouped under three industrial areas: Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), and Computer-Aided Graphic Arts (CAGA).

An introductory course relevant to all eleven programs was developed and offered initially in June 1980. An advanced applications course was offered in the Mechanical Design program the following semester, and an Electrical Applications course in the fall of 1981. Other applications courses are planned for Civil Technology, Architectural Technology, Numerical Control, and Graphic Arts.

Managers from industry (e.g., a local CAD manager) teach some of the courses, and employees from local industries attend classes with regular full-time students. Employee-students are primarily designers and draftpersons but may also include managers and supervisors from industries anticipating or already using computer graphics equipment and procedures. During the fall of 1980, a one-day seminar on computer graphics applications in the areas of mechanical, electrical, and civil engineering, and in numerical control was offered by MATC and was attended by 174 participants representing sixty industries and nine colleges. A one-day seminar focusing on both CAD/CAM and business graphics was also offered in the fall of 1981. This seminar was attended by 220 persons representing 101 organizations. The 1981 and 1982 seminars were cosponsored by the Wisconsin chapter of the National Computer Graphics Association and MATC.

Funds for development of the computer graphics curriculum, retraining of faculty, and preparation of a training facility were provided by a National Science Foundation (NSF) grant. Computervision Corporation provided equipment and software, and in June of 1980 the system was installed. There currently are four computer graphics storage tube design stations, with digitizer/plotters, minicomputers, and associated software, partially funded by Computervision Corporation and NSF.

The development of MATC's computer graphics curriculum is unique in that, although advisory assistance from industry was utilized, industry itself was just becoming familiar with the technology and had not exhibited a need for large numbers of trained computer graphics technicians. Industry's interest in becoming acquainted with computer graphics is evidenced by an enrollment at MATC of 124 continuing education students during the first two semesters. Many of these students had professional backgrounds ranging from designers and draftspersons to managers and supervisors of user and prospective user companies. A waiting list of 260 persons has accumulated for the fall 1982 semester and enrollment has been expanded to 160 persons per semester.

As a result of MATC's leadership role in the development of a computer graphics curriculum and the promotion of its Partners in Progress program, the National Computer Graphics Association (NCGA) established its Wisconsin state chapter headquarters at MATC. This provides ready access to the professional association for stronger linkages with education and community leaders. The NCGA chapter plans include: holding seminars and workshops in the computer graphics applications areas; creating a forum for users, vendors, industrial managers, and educators; developing a resource center for applications information; and publishing a newsletter to inform industry and the education community of recent events in the computer graphics area.

The Allen Bradley/MATC Connection

The Allen Bradley Company cooperated in forming and supporting MATC's core curriculum in computer graphics through its membership in Partners in Progress, participation in MATC's advisory committee on computer graphics, and through other activities. The most visible activities have involved aid in the development of MATC's computer graphics faculty through a skill-work program (where instructors spend a summer working and gaining practical, hands-on experience at Allen Bradley), and through funding the transportation of MATC instructors to industrial shows. MATC's experienced instructors aid in skills upgrading and technology transfer by passing along their state-of-the-art knowledge to Allen Bradley employees, whose attendance at the MATC summer or evening courses in computer graphics is underwritten by the company. Allen Bradley also has hosted a four-day workshop in computer graphics for managers at its Milwaukee plant. The workshop instructor was on the MATC computer graphics faculty. Finally, Allen Bradley actively recruits MATC graduates whose machine design or other technical education has been supplemented by the computer graphics courses.

MICROELECTRONICS

DIGITAL EQUIPMENT CORPORATION and FRANKLIN INSTITUTE *Focus:* Development of an exemplary minicomputer technician training program

Digital Equipment Corporation (DEC), Boston

The Boston-based Digital Equipment Corporation (DEC) is currently said to be the world's largest manufacturer of minicomputers. It also produces a range of related digital equipment. The company had forty-four thousand employees in 1980, including personnel providing field service of DEC equipment nationally.

Prior to 1975, ex-servicemen with electronics service experience were hired to fill most of DEC's field service needs. However, this source became insufficient and the company sought new sources of field service technicians. The need was for persons with extensive "hands-on" training in troubleshooting and servicing digital equipment. Electronics technology programs in postsecondary vocational schools were typically more theoretical and broader in scope (e.g., requiring coursework in communications areas) than was appropriate for DEC's needs. Graduates of such programs, although well-suited to work in a research and development environment under engineering supervision, were not adequately trained to work as service technicians in the digital equipment field. (DEC hires graduates of electronics technology programs to work in design and research, but for those hired to service their products, the company has had to provide extensive additional training.)

The Bureau of Labor Statistics has projected an increase of 154 percent in computer service technician jobs between 1978 and 1990, making it the fastest growing computer-related occupation. DEC planners and the president of the company anticipated the increase, as well, and made a long-term commitment to the development of a training program to prepare individuals to work as computer service technicians. The result of DEC's commitment was the development of the Minicomputer Technology Program (MTP).

The MTP involves participating educational institutions in a contractual arrangement to offer training in return for equipment and other benefits. Allowances offered by DEC to the MTP schools include outright gifts, or allowances, of computers and associated equipment. In addition, the company provides training to the schools' instructors at its own training facilities. Twenty-four schools are now involved in delivering MTP training. (Franklin Institute of Boston is one of the earliest.)

DEC selects schools to participate in the MTP on the basis of several considerations. Since DEC expects to hire a substantial number of the graduates, the schools must be located in geographic areas where computer business activity is concentrated. Generally, these are urban areas. DEC looks for schools with existing curricula in electronics, and considers the ease of adding a computer technician program, as well as the tenure of the faculty. In addition, DEC looks for schools that will aid the company in meeting its equal opportunity and affirmative action goals.

Although DEC suggests a curriculum for the MTP, participating schools work with DEC to adapt the curriculum to their individual circumstances. The MTP installed at each school is reviewed at least annually by DEC Educational Services staff in consultation with the company's field service representatives who are most familiar with the school and its graduates. Recommendations are formulated and presented to the school's program advisory committee. The objective of these reviews is to improve the marketability (and, thus, the value to DEC) of the MTP graduates' skills.

Although DEC is in competition with other employers for these graduates, it has been successful in attracting more than half of all MTP graduates. The company is pleased with the success of the program because graduates now are able to become productive after only two weeks of employment, whereas formerly eighteen weeks were needed.

There are several factors that appear to be vital to the success of DEC's Minicomputer Technology Program. Foremost is the corporate commitment to a long-term investment in training. The company's commitment also goes well beyond its allowances of equipment and training of instructional staff. Indicative of DEC's philosophy is its willingness to contribute heavily to a training program that does not guarantee the company a supply of skilled employees except at competitive wages.

Franklin Institute, Boston

The Franklin Institute is a private technical college offering a variety of one- to three-year instructional programs based on science, engineering, and technology. Associate degree program areas include the engineering technologies and the industrial technologies. A fairly small school, Franklin serves an average of one thousand students each year. It operates its own in-house computer center, permitting time-sharing for unlimited use by faculty and students. The Institute maintains an affiliation with the Boston University College of Engineering.

Franklin Institute chose to offer the DEC-affiliated Minicomputer Technology Program as a one-year program leading to a certificate of proficiency. This choice was made in order to reduce the cost to students and to provide as much access to students as possible. (Franklin is the only MTP school offering a one-year program; the approximately two dozen other cooperative institutions have implemented a two-year curriculum leading to an associate degree.)

The objective of Franklin's version of MTP, called the Computer Service Technology Program, is to respond to the current and anticipated demand for technicians who can install, troubleshoot, repair, and maintain computer equipment and digital electronic systems. To this end, the program material and laboratory activities emphasize the following areas of preparation: a solid foundation in electronic circuits, digital logic, and integrated circuit technology; computer systems and programming; system installation and checkout procedures; theory of operation and system component troubleshooting; and employer representation and customer relations. Report-writing and topics in mathematics are integrated into the appropriate technical courses. The Computer Service Technology Program devotes more than half of the total instructional hours to laboratory experience with "hands-on" emphasis.

To accommodate the program, Franklin spent $75,000 to prepare an appropriate facility, and employs a full-time technician to maintain the equipment utilized in the program. The program budget also provides for annual replacement of equipment damaged as a result of the high-use laboratory classes.

The DEC/Franklin Institute Connection

The flexibility of Franklin Institute seems to be the greatest factor on the part of the school in implementing and maintaining its version of DEC's Minicomputer Technology Program. Responsiveness of the Institute's program advisory committee to DEC's annual curriculum review and recommendations, and its continuing budgetary commitment to replace program equipment, are other important factors. Franklin is satisfied with MTP, not only because of he outstanding relationship it affords with DEC, but also because of increasing enrollments. The Computer Service Technology Program is now at capacity (sixty-three persons) for the next class, and the Institute is considering an evening program as well as an optional associate degree program. Computer Service Technology is now one of Franklin's three regularly offered electronics technology programs.

There are a number of other factors that contribute to the success of Franklin's Computer Technology Service Program, and to Digital's MTP programs in general. Foremost is the company's commitment to a long-term investment in training. This commitment is evidenced not only by allowances of equipment and provision of training for MTP school instructors, but by the fact that the company is willing to compete with other employers for graduates of MTP programs. It is also reflected by the company's organization, in which Educational Services reports directly to the senior vice-president for Customer Service, and by its relations with Franklin and other MTP schools. Franklin's experience is that DEC is far more generous in its support than is actually required by its formal agreements. DEC, on the other hand, is satisfied with the outcomes of Franklin's and other MTP schools' programs, because graduates hired by DEC are now able to become productive after only two weeks of employment, whereas formerly eighteen weeks were required.

MEDICAL TECHNOLOGIES

TUFTS-NEW ENGLAND MEDICAL CENTER (TNEMC)

and

FRANKLIN INSTITUTE

Focus: Development of a cooperative medical electronics training program

Tufts-New England Medical Center (TNEMC), Boston

The rising costs of health care are frequently attributed (in part) to the increasingly sophisticated equipment being used by health care facilities. Such equipment includes ultrasound, thermal, and x-ray diagnostic machines, cardiovascular and other monitoring systems, dialysis and cardiopulmonary machines, and—on the immediate technological horizon—automatic gene-synthesizer machines, as well as a host of other devices. No modern hospital can operate without technicians to operate, calibrate, maintain, and repair such equipment.

The Tufts-New England Medical Center (TNEMC), located in Boston, is a 452-bed hospital providing all types of medical care except obstetrics, primarily on a referral basis. In addition to the seventeen residency programs for physicians, TNEMC provides thirty-eight allied health training programs, including the Medical Electronics Technology Program developed and operated by Franklin Institute and the Medical Engineering (ME) Department at TNEMC.

The ME Department was created in 1971 and is supported independently from fees generated by servicing intensive-care and general floor equipment as well as equipment for the Departments of Radiology and of Anesthesia. In 1974, a Bio-Medical group was created to develop equipment for the handicapped. Starting in 1976, the ME Department began a program of general hospital service to all devices not in the Radiology, Anesthesia, or Rehabilitation Departments, and is currently providing services to other hospitals in the Boston area.

The ME general hospital service department consists of ten full-time staff who completed over sixty-one hundred repairs and five thousand preventive maintenance inspections in 1980. Seventy percent of staff time is billed to other departments, which pay for ME services. The ME group does little design work and almost no fabrication of special devices.

The Medical Electronics Technology Program for training medical electronics technicians started in 1973 in affiliation with the Franklin Institute of Boston. The curriculum design was a joint effort by individuals representing Tufts University, TNEMC and affiliates, and the Franklin Institute, after consideration of existing programs and suggested curriculum components.

Both Franklin Institute and the Medical Center have benefitted from their teaching relationship. TNEMC provides Franklin's medical electronics students with clinical internship positions at the Medical Center, including hands-on experience with the latest equipment in use at the hospital and at affiliated medical facilities. In addition, some of the courses in the Medical Electronics Technology Program are taught by TNEMC personnel.

The Medical Center has benefitted from the relationship with Franklin in a number of ways. There is greater ease of finding and recruiting qualified technicians with realistic, work-site experience and familiarity. Technician interns from Franklin provide part-time help to TNEMC, and part of their tuition is contributed to the budget of the Medical Engineering Department. Finally, TNEMC receives access to specialized test equipment owned by the Franklin electronics labs.

Franklin Institute, Boston

As was mentioned in the Microelectronics case study section, the Franklin Institute is a private technical college in Boston offering a variety of instructional programs based on science, engineering, and technology. A Medical Electronics Technology Program was in operation at Franklin at the time that the discussions between Franklin faculty and Tufts-New England Medical Center staff concluded that there was a need for different and more comprehensive training for medical electronics technicians.

The discussions and notions for a new kind of medical electronics training program stemmed from a disagreement (on the part of both Franklin and TNEMC staff) with the conclusions of a study done by the Technical Education Research Center analyzing the job skills needed by medical electronics technicians. The study (reported in 1972) suggested that medical electronics technician trainees required skills such as those used by artisans or radio/television repairers, whereas the Franklin and TNEMC staff, who had hands-on experiences with medical electronic equipment, felt that the best preparation for such technicians should be a combination of engineering training and knowledge of human physiology.

A professor of electronic engineering technology from Franklin, a professor of engineering design from Tufts University, a research fellow from Boston University, and the head of the Medical Engineering Department of the TNEMC met informally once a month for about a year, planning and designing the specialty areas to be developed into new courses or added to the existing courses in the extant Medical Electronics Technology Program at Franklin. In addition, Franklin and TNEMC planners made use of the advice of other industrial advisors and medical technology specialists. A survey was conducted with technology specialists from industry and other medical institutions to determine the kinds of people being hired or currently working as electronics technicians, and to project the trends for the technical skills that would be needed in the field in the future. The survey confirmed Franklin and TNEMC staff members' original premise: the Technical Education Research Center's study did not anticipate the future skill needs, especially in engineering and knowledge of physiology, of medical electronics technicians for the late seventies to early eighties.

The Medical Electronics Engineering Technology Program now established at Franklin Institute (and in operation since 1974) is a two-year program of study and cooperative work experience leading to an Associate in Engineering degree. It provides a unique blend of subject matter and advanced courses in mini- and microcomputers, electronic devices, electric and electronic circuitry theory, medical instrumentation, human physiology, medical instrument safety and grounding techniques, semiconductor circuitry, and principles and design of medical electronic equipment.

Laboratories of the Franklin Institute Electronic Engineering Department are used for courses in electrical and electronic circuitry and semiconductor circuits. Those portions of the program taught at Franklin are essentially the same as the curriculum for the Electronic Engineering Technology Program.

In-hospital laboratory experience is provided through affiliations with the Medical Engineering Department of TNEMC. Students are directed by hospital technicians in the repair, calibration, and applications of medical devices. Courses in human physiology are taught at TNEMC and are modified versions of the same physiology courses given to medical and dental students at the hospital. Students also observe and participate in animal experiments conducted at the research facilities of the hospitals in order to gain experience in the use of medical equipment on live subjects. Students have the use of the medical school's library and are given assignments requiring use of the library.

During their final semester, students gain clinical experience through a rotating "internship," similar to the training of a medical student on rounds, involving working in a number of Boston-area hospitals. Students are part of a team responsible for particular tasks, and they assist in all work performed. Students are to observe a variety of approaches to both technical and human problems that are commonly encountered in the use of the medical equipment. Last-semester students are also matched (one to one) with an experienced, professional hospital technician who serves as a mentor, friend, critic, and role model. This final part of the program is intended to help the students accept and get used to hospital environments.

Franklin accepts a new class of approximately eighteen to twenty students for the program each year, keeping the number low because of the limitations of the medical facilities and the demands of the individualized training at the hospitals. The students themselves reportedly take an unusually mature attitude toward their training and toward a career in the medical area. The program is very demanding, and could readily be spread over a three-year period. Because of its rigor, only about 60–65 percent of each entering class graduates.

Graduates of the Medical Electronics Technology Program are prepared for employment as medical electronics technicians, biomedical engineering technicians, biomedical research assistants, medical instruments manufacturers' representatives, and biomedical equipment technicians. Most of the graduates have thus far gone to work in hospitals, and 10 percent of them have been employed by TNEMC. The program is gaining national recognition with the annually increasing recruitment of graduates by hospitals distant from Boston.

The TNEMC/Franklin Connection

Administration of the Medical Electronics Technology Program involves a contractual arrangement between Franklin and TNEMC. Franklin has formal jurisdiction over the program but, in practice, the courses and training conducted at TNEMC and affiliated hospitals are governed by the faculty in charge there. Tufts and the affiliated hospitals update and upgrade the content of the courses taught within their domains, and train the students on the latest equipment in use at the hospitals. The ability of the two institutions to coordinate the teaching materials is sometimes strained, particularly where the instrumentation taught at the hospitals is out of sequence with the circuitry classes at Franklin. In some cases, advanced circuitry and other technologies in medical instrumentation and equipment (such as ultrasound and nuclear technology) are not covered in the classes at Franklin at all, and must be covered by those teaching the instrumentation at the hospitals.

Tufts-New England Medical Center has found the cooperative arrangement with Franklin rewarding in a number of ways. The financial support provided by Franklin for teaching staff contributes to the salaries of four full-time personnel at TNEMC. The expansion of TNEMC reference material and test equipment is also significant. The clinical rotation of students, which is coordinated and scheduled by TNEMC, decreases the work load on TNEMC technicians. Both TNEMC and affiliated hospitals realize a benefit in being able to hire qualified graduates who have had practical experience at the work site, and who know the specific equipment, procedures, standards, and policies of the work site.

The program arrangement between TNEMC and Franklin has benefitted Franklin by enabling its own instructors to be kept current with new medical equipment technologies, and by sharing the expenses, facilities, and expertise of the hospital. The latest equipment is available for training without having to set up a special lab at Franklin. Certain courses, such as those in human physiology, are more aptly taught by the medical personnel at Tufts than could probably be taught in classrooms at Franklin. The students benefit particularly in that they receive hands-on experiences and move between facilities, which gives them competence and familiarity in a variety of active work settings.

A number of factors are keys to the overall success of the program. Foremost among these is the high quality of the hospital professional staff who teach. The director of medical engineering at TNEMC and the instructor in physiology at Tufts University School of Medicine are both presently involved. These people are enthusiastic and dedicated to the excellence of the program.

A second factor is "the hospital connection" by which students are exposed to the latest equipment and techniques, and are provided with role models. The hospital-based portions of the instructional program are provided to Franklin at a modest cost.

A third factor is the strong engineering background acquired by students through a spectrum of courses taught at Franklin. A solid basis in circuitry theory, troubleshooting, digital logic, and mathematics enables program graduates to understand, from a knowledgeable engineering perspective, the kinds and sources of problems as well as the normal parameters of medical instrumentation. Such knowledge is of particular importance in gauging the accuracy of medical data collected by electronic diagnostic or monitoring equipment, and in determining whether certain anomolous data reflect actual patient readings or are artifacts of the electronics themselves.

A fourth factor in the success of the program is the support of TNEMC and other eventual employers in the Boston area who participate in the clinical internship aspect. These linkages provide for curriculum revision, and they function as information resources on the latest technologies and procedures in the field for persons already employed as medical electronics technicians or in related technical occupations.

ADVANCED MANUFACTURING

CINCINNATI MILACRON INCORPORATED

and

PIEDMONT TECHNICAL INSTITUTE

Focus: Development of a center for robotics technology innovation, training, and teacher inservice training

Cincinnati Milacron Incorporated; Cincinnati, Ohio

Cincinnati Milacron is the world's leading producer of metal-cutting and plastics processing machinery and one of the leading suppliers of robots in the United States. The company earned its reputation for manufacturing precision machine tools; however, its product line has been expanded to meet other industrial needs. Newer product lines include specialty chemicals, grinding wheels, cutting fluids, printed circuit board materials, and semiconductor materials.

Milacron employs more than fourteen thousand workers in thirty-two plants. Eighteen plants are located in the United States, mostly in southwestern Ohio, and fourteen are distributed internationally.

Cincinnati Milacron is currently engaged in the manufacture of a line of high-technology robots, the T3. This kind of robot can execute lengthy programs and its "hand" can follow complex paths in the process of completing a program. The latter capability is due to a two-dimensional search-and-find capability, one of its several software options. The T3, known as the "Cadillac" of robots, uses up to six computer-controlled axial movements to complete a variety of industrial operations such as spray painting, welding, power tool operation, loading/unloading, and parts inspection and handling.

Cincinnati Milacron's robotics technology was developed via its internal research and development activities. Approximately eight years were required to translate ideas into reality.

Milacron is one of a growing number of manufacturers of industrial robots (including Devilbiss; Unimation Astrosystems, Inc.; Auto-Place; Robot Systems, Inc.; Nordson; and others), all of which claim that their machines can lower production costs and upgrade quality by performing faster and more reliably many tasks that are too dangerous, boring, or are otherwise unsuitable for human operators. The growth in this industry has been spurred by the need for manufacturers to cut labor costs and improve quality, and by technological breakthroughs in microelectronics, all of which facilitated the current state of the art.

Robot sales in this country are growing at an annual rate of thirty-five percent, and could quadruple by 1985. Cincinnati Milacron sold three times as many robots in 1979 as it did the year before, and expectations are for sales to triple again in 1980 to $32 million. Optimistic forecasters are predicting general sales of robotized manufacturing equipment in the United States to reach $2-4 billion by 1990. The leading user of robots today is Japan, with ten thousand machines in place, followed by the United States with three thousand, and by West Germany with 850.

As the sophistication of robots increases and their purchase price decreases, the following forecasts can be made:

- By 1982, 5 percent of all assembly systems will use robotics technology
- By 1985, 20 percent of the labor in the final assembly of autos will be replaced by automation
- By 1987, 15 percent of all assembly systems will use robot technology
- By 1988, 50 percent of the labor in small component assembly will be replaced by automation
- By 1990, the development of sensory techniques will enable robots to approximate human capability in assembly.

With increasingly widespread use of industrial robots, there is and will continue to be a need for specially trained persons to assist in installation. servicing, and maintenance operations. Perhaps the single largest need initially will be for programmers to design the computer command packages for performing various industrial robot operations. These programmers will need the assistance of technicians who understand how robots work and who can assist in the programming process. To become well-rounded technicians, these individuals (as well as those performing installation, field maintenance, and service work) will require mastery of all the related basic subjects—electronics, hydraulics, pneumatics, and programming. However, to date only one postsecondary facility (Macomb County Community College, Warren, Michigan) offers an operational, full-scale two-year training program for students of robotics.

Cincinnati Milacron, looking ahead to the continuing growth of robotics and the correspondingly expanding need for trained robotics technicians, has become involved in advising and aiding post-secondary institutions in developing robotics training programs. One school with ongoing linkages with Cincinnati Milacron is Piedmont Technical Institute, in Piedmont, South Carolina. Piedmont Tech is currently developing training programs in robotics for instructors, and will eventually expand the programs to train students. To aid in the training, Milacron has placed robotics equipment on consignment at the Piedmont facility, and has provided consultation and technical assistance on robotics systems to the Piedmont staff. Milacron's commitment to support robotics training, combined with some unique characteristics of Piedmont Technical Institute, will help develop high quality, comprehensive training programs within the next few years.

Piedmont Technical College Robotics Resource Center

Piedmont Technical College is one of sixteen two-year technical colleges in South Carolina's Technical Education College System (TEC). TEC's mission is to aid economic development in the state by helping to create jobs and by training people for those jobs. Recognizing the rapid changes in technologies used by business and industries, the leaders of TEC developed the "Design for the Eighties," an ambitious program to meet the expected needs of South Carolina industries during the next five years.

As part of the "Design for the Eighties," five advanced technology resource centers have been established in as many technical colleges, with plans to develop others as needed. Piedmont Technical College houses the Robotics Resource Center, with other centers at Midland Technical College (Advanced Office Occupation Resource Center), Greenville Technical College (Advanced Machine Tool Resource Center), Tri-County Technical College (Microelectronics Resource Center), and York Technical College (Computer Resource Center). The centers represent a major commitment on the part of TEC to incorporate state-of-the-art technology into its one- and two-year training programs in all sixteen colleges in the system.

Development of the Robotics Center at Piedmont began in April 1981, as a direct response to the construction of Cincinnati Milacron's robot manufacturing plant nearby. Like all of the resource centers, it will serve three major objectives: (1) to impart knowledge and training about each specialty area to faculty at the other technical colleges in the TEC system; (2) to aid in transferring new technology to local industries and businesses through seminars, conferences, training programs, and workshops; and (3) to serve as a learning center for students.

One of the incentives for Cincinnati Milacron to locate its new plant in South Carolina was the provision of a pre-employment training program through the South Carolina Special Schools Program. In 1979, when the robot manufacturing plant was under construction in nearby Greenwood, Milacron placed seven pieces of equipment in the Piedmont Technical School and provided experienced plant personnel to conduct training sessions in the use of Numerical Control (NC) production equipment. The pre-employment training sessions focused on machine operations skills necessary to produce robots; however, the Robotics Center will concentrate on technician-level skills for implementing and maintaining robot systems.

When the Resource Center was visited in July 1981, it was preparing to begin this fall to provide seminars and courses for instructors from other TEC colleges. The two instructors assigned to the Center were completing their own inservice training at that time, and had recently attended a one-week training session at the General Electric Heavy Industrial Robotics Lab in Schenectady, New York. They also spent six weeks in a work experience program at the Cincinnati Milacron plant. Additional visits had been made to the Cincinnati Milacron Robotics Conference in Ohio, to the Wright-Patterson Air Force Base CAD/CAM Center, and to robotics manufacturers in Michigan.

Through the "Design for the Eighties" programs a total of $32,000 was provided for inservice and developmental expenses. A full year of release time for one of the Center's instructors was provided by these funds. The information and experiences gained from the visits and workshops helped in formulating the Center's plans for selecting and locating equipment and developing curricula.

Curricula currently in the planning stages at the Center will initially include short courses for faculty inservice training and private industry personnel, with special training sessions for two-year technician graduates expected to begin in twelve to eighteen months (summer, 1982). Long-range plans are to provide a full one-year certificate program in robotics for electrical, civil, and industrial engineering technician students. The format of the curriculum is envisioned as a series of modules that can be organized to serve a variety of learning objectives. The use of overhead projector transparencies and edited manufacturers' media presentations are potential techniques for creating the flexible modularized curriculum. Two robots have been loaned to the Center: a highly sophisticated T3 robot from Cincinnati Milacron valued at $80,000, and a simpler robot from the Seiko Corporation valued at $40,000. State support, budgeted at $67,000, has been allocated for the purchase of other robots and related equipment.

Plans are underway also to prepare a truck–van to serve as a mobile classroom and lab. The mobile unit, containing several smaller robots and a full range of instructional resources and demonstration devices, will travel to the other technical colleges to provide both instructor inservice training and student training sessions. The mobile unit is further expected to help extend the Center's capacity to serve as a technology transfer agent by providing on-site early orientation and training to existing industries, thereby aiding their more rapid adoption of new robotics technology.

Although the Center was not fully operational when visited, it represents an innovative and forward-looking approach to meeting the future training needs for technician-level personnel as the use of robotics becomes more widespread among South Carolina industries. To help ensure that the Center's training programs and technology transfer efforts are appropriate and responsive to changes in robotics technology and industries' needs, a national advisory council of robotics researchers, developers, manufacturers, and users is currently being assembled. Members are expected to include Georgia Tech, Purdue University, Rensselaer Polytechnical Institute, and Carnegie-Mellon University, as well as knowledgeable representatives from the Heavy Industrial Robot Applications Lab of General Electric, from Robot Systems, Inc., in Atlanta, from the McDonnell-Douglass Corporation, and from Cincinnati Milacron.

The Milacron/Piedmont Connection

The cooperative relationship between Cincinnati Milacron and Piedmont Technical College began with the Special Schools pre-employment training program, the availability of which contributed to Milacron's decision to locate its plant in South Carolina. The relationship was strengthened by the TEC System administration's decision to locate the Robotics Resource Center at Piedmont, placing it in close proximity to the Milacron plant.

Milacron has contributed to the development of the Center by providing a T3 robot and by providing inservice experiences for the Center's staff. Milacron has hired technician graduates from Piedmont programs in electronics and industrial technology.

The Piedmont Robotics Resource Center is an example of a direct response to current and future changes in an advanced technology by a two-year technical college, with the assistance of private industry and state support. The cooperative relationships between the Center and private industries that have been developed clearly demonstrate the potential that exists for postsecondary schools and industry to work together to meet current and future employment needs. An additional benefit to be gained by such efforts should be an increase in productivity and economic growth, both locally and nationally, as new, more productive technologies are brought into full operation.

ADVANCED OFFICE TECHNOLOGIES

PORT AUTHORITY OF PORTLAND

EMPLOYERS BENEFIT INSURANCE COMPANY

and

PORTLAND COMMUNITY COLLEGE

Focus: Development of associate degree programs in records management and word processing technologies

Two businesses were visited and their information production and management systems were reviewed to gain a better understanding of the impact of new information and records management technologies on training and education requirements for employment in these and similar firms. The Port Authority of Portland and Employers Benefit Insurance Company are local leaders in the application of the advanced office technologies to improve productivity and to reduce the cost of information processing and management systems. Both businesses have linkages with Portland Community College for training in advanced office technologies.

Port Authority of Portland, Oregon

The Port Authority of Portland is a quasi-governmental agency that owns and operates the International Airport and the Marine Terminal in Portland, Oregon. Approximately 275 employees are involved in administrative functions, including engineering, legal, financial, and personnel staff. Total employment in the Port Authority is approaching 650 individuals. The Port Authority has been in existence for ninety years.

The Records Management Department serves all administrative departments and employs a staff of seven, including a librarian. The department is responsible for managing all incoming and outgoing information for the entire Port Authority operation, which includes not only current records, but also, on occasion, records and correspondence going back twenty-five to fifty years or more. The Port Authority operations involve a high volume of information handling, storage, and retrieval.

The staff of the Records Department reviews all incoming mail and selects out essential documents, keeping the original and sending a copy to the appropriate recipient. The original copies are then photographed for entry into either the microfiche or microfilm data-retrieval system.

The major benefits of implementing the Records Management Department and electronic records storage and retrieval system are a 98 percent reduction in floor space for file storage and related reductions in file cabinets and supplies. Secretarial productive work time in other departments has been increased because the Records Department staff performs the majority of records handling tasks, including purging all departmental files annually. Executives and managers can quickly access needed information in the system via electronic desk-top scanners. Additionally, system security and control has been improved significantly.

The Records Department uses two manually operated microfilm cameras purchased at a cost of $20,000 and one automatic camera for filming large volumes (five thousand photographs per minute) of material at a cost of $8,000. Annual supply costs for the system are approximately $2,000 per year. The efficient life expectancy of the equipment is from five to ten years.

The manager of the Records Department expressed the opinion that while the "paperless office" is not yet a reality in most companies, there will be a continual increase in businesses' use of electronic equipment and a need for trained employees to operate modern information management systems.

Employers Benefit Insurance Company (EBI); Portland, Oregon

The EBI Company, in operation for eleven years, is the largest volume private carrier of worker's compensation in Oregon and, as such, handles approximately six thousand claims a month plus its other insurance business clients. The company instituted a Word Processing Center (WPC) six years ago to handle the growing volume of paperwork. Seventeen people are employed in the WPC, fourteen of whom are operators. The Center serves 290 employees, with 80 percent of the Center's work load coming from the Claims Department. Monthly output from the Center averages seventy-five to eighty thousand lines of final draft typing, with an error rate consistently less than one percent. On an average day the Center will complete 250 letters containing several pages each, plus additional reports that average 100 pages or more in length. The output of the fourteen word processor operators is estimated by the Center manager to be equal to the output of fifty regular typists, a productivity gain ratio of 3.5 to 1. Most of the material, about 80 percent coming to the Center, is in the form of tape transcriptions; the remaining portion is typed copy. Normal turnaround time for regular scheduled work is one to three days, whereas rush materials can be completed in one day.

A feature of the word processing equipment in the Center that contributes to faster typing speed is the Dvorak keyboard. The key configuration on the Dvorak keyboard was scientifically determined by its inventor, August Dvorak, and being different from the key arrangement found on the common typewriter, requires relearning by experienced typists. Once learned, it contributes to a net gain in typing output over the traditional key arrangement, particularly when typing is done continuously for several hours at a time.

In addition to special training on the operation of word processing equipment, operators must learn about the various capabilities of the system in order to take full advantage of the technology. Operators (called word processing technicians at EBI) must also have a high level of fluency in spelling, grammar, and punctuation. Shorthand skills, which have traditionally been associated with secretarial positions, are not required.

The first and second year of the Center's operation involved many adjustments, as work flow patterns and procedures were worked out to achieve the most efficient system possible. The manager of the WPC provided orientation and training to managers of other staff to facilitate the transition from using individual secretaries and typing pools to using the centralized WPC. During the transition period, the company did not need to hire new employees with special training. Such a need did appear about the third year of operation. At that time Portland Community College began developing a training program in response to the emerging local employment opportunities for word processing jobs.

Portland Community College; Portland, Oregon

Portland Community College dates back to 1889, when a public night school was started in the old Portland High School to serve foreign-born residents and those who had left school for jobs. Officially, the school became a comprehensive community college in 1961 as an extension of the Portland Public Schools Adult Education Division. By 1968 the college separated itself from the school district by winning voter approval for a metropolitan area education district consisting of sections of five counties. Voters also approved a unique tax base that year to provide funds for capital improvements as well as operations.

The college district encompasses fifteen hundred square miles, including all of Washington County and parts of Multnomah, Clackamas, Yamhill, and Columbia Counties. The college serves nearly seventy-five thousand students each year. Operational costs of $1,344 per student are the lowest in the state.

Courses at Portland Community College (PCC) are organized and integrated into a broad variety of programs. At PCC students may choose from associate degrees and certificate career programs, college transfer programs, special interest and enrichment courses, apprenticeship training, management/supervisory development, and high school completion courses.

Microprocessor applications and related computer technology have brought about dramatic changes in modern office systems in Portland over the past ten years. In response to the changes that had taken place by 1977 in the records management departments and word processing centers in Portland-area businesses, the faculty of PCC's Department of Business Education began to develop new associate degree programs in records management and word processing. Advisory committees for both records management and word processing were established with representatives from the Port Authority, EBI, and other businesses playing key roles in planning appropriate programs.

A major problem was encountered in obtaining program approval from the Oregon State Department of Education. PCC was required by state rules to provide documentation of job opportunities as part of the approval application process. The job titles for word processing technicians and managers and for records management technicians and supervisors were deleted from the U.S. Department of Labor's *Dictionary of Occupational Titles* (DOT) in the editing process, leaving only low-level entry and higher-level manager job titles. The two-year curriculum for the programs focused on mid-level jobs such as junior and senior word processing technician and supervisor, forms analyst, report analyst, record center supervisor, and records management junior analyst. Because of the title deletions, there were no state employment data for these mid-level occupational openings.

The PCC faculty, in conjunction with the advisory committees, began to collect the necessary evidence to show that there was truly a growing need for the programs. Analyses were conducted of existing jobs and career progressions in local companies. National studies and data from the American Records Management Association were collected and analyzed, and appropriate information was compiled and presented to the Oregon State Department of Education. The entire process took two years for the initial planning stage through the final approval, which came in 1979. The first courses were started in the fall of 1980, with the first graduates completing the programs in June 1981.

Because the state department stipulated that the word processing courses be considered supplementary occupational training for upgrading incumbent workers, most of the courses were initially scheduled in the evenings and as seminars and conferences. The series of courses required to qualify or upgrade a person for employment as a word processing operator can be completed in six months at PCC, which is about the same amount of time required for on-the-job training of experienced typists at EBI.

A different problem encountered by the PCC faculty is the mistaken image many managers in local businesses have of records management technicians as glorified file clerks. There has been some resistance on the part of the business community to change old concepts and recognize the advantages of modern office technology. However, once the new systems become operational and managers see the improvement in productivity and reduced cost, they are very supportive of the changes. With enthusiasm for the new approaches increasing in the Portland area, the demand for trained personnel from the college has increased, as has student interest in the programs.

The Port Authority/EBI/Portland Community College Connection

The close cooperation between Portland Community College and its advisory committees for the Records Management and Word Processing Programs represents an expansion and elaboration of the typical relationship between such entities. Members of the committees worked with faculty members on a weekly basis, often in company offices or meeting rooms, to identify job responsibilities, establish performance requirements, develop courses of instruction, and validate the existence of related job openings in the Portland area. When the faculty encountered difficulty in gaining program approval by the state, they were assisted by the advisory committees in gathering appropriate evidence of the need for the programs to respond to emerging jobs in the area. Advisory committee members and PCC faculty also met with State Employment Division personnel to review and reclassify employment statistics to reflect, more accurately, the emergence of records management and word processing occupations.

One PCC faculty member was released from regular teaching duties for a year and a half to work with the advisory committee members in developing the Records Management Program. She and other faculty members, using the list of competencies developed by the advisory committee, reviewed PCC's existing courses related to the field, and selected those that provided appropriate educational experiences. One existing course was revised and four new courses were developed, then combined with other courses at PCC to create the Records Management Program. The four new courses included Introduction to Micrographics, Forms Management, Records Systems and Design, and Record Management Co-op and Seminar.

The Records Management Program at PCC is one of the most up-to-date and comprehensive currently being offered in the United States, according to the results of the Association of Records Managers and Administrators, Inc., and the Institute of Certified Records Managers Joint Study (1981). Much of the Records Management Program's and the Word Processing Program's success stems from the close involvement of companies such as the Port Authority of Portland and EBI. Through their participation on 'C's advisory committees, they helped not only to make the development of two high quality training programs possible, but made it possible for PCC to overcome a significant bureaucratic blockade in getting the programs approved by the state, by becoming involved in helping PCC gather and present employment evidence and forecasts that may not have otherwise been accessible to the school.

DISCUSSION

The Case Studies: Problems and Solutions

The five collaborative programs, reported as case studies, represent various approaches that schools and companies are using to develop training programs to meet local and state job-skill needs, both immediate and future. Information gathered during the site visits and through discussions with other employers and school personnel has been used to identify a number of conditions that tend to hamper efforts by both groups to respond to changing technology, as well as the approaches used to resolve the conditions.

Program Planning and Development

The first and most significant problem for all of the programs was the rapid pace of technological change, which affects job performance requirements and standards, work environments, recruiting practices, employment opportunities, and educational requirements. Many of the rapid changes are the result of advances in microelectronics, which have contributed to the emergence of other new, more efficient and productive technologies that are being implemented by companies in response to rising costs, increased competition, and the creation of new product markets.

Because of the revolutionary nature of many technological changes, there is often no existing cadre of experienced workers and few technical experts from whom information and advice can be gleaned to aid in program development. Schools attempting to devise programs for new technology areas found that they had to draw on experts from outside their local area or state, often experts from corporate and university research and engineering departments. In some cases, emerging technologies were so new (e.g., computer graphics and CAD/CAM) that both industry and schools found themselves without expertise, and they had to learn about their individual and mutual needs together.

In every one of the case studies, the collaborating companies served on advisory committees for the schools along with other companies, university researchers and engineers, professional associations, and so forth. In some cases, the need for the new training programs was first recognized and the planning and development activities were initiated by the schools (e.g., Portland Community College). More often, the recognition and impetus for the programs were simultaneous or mutual (e.g., Tufts/Franklin, and Allen Bradley/Milwaukee Tech). In the case of Piedmont, initiation of the program area was mandated by the Technical Education College (TEC) System, which is part of South Carolina's economic development plan. Digital Equipment Corporation (DEC) was the initiator of the Minicomputer Technology Program, which was adapted and implemented by Franklin Institute, as well as by twenty-four other postsecondary institutions.

Advisory committees served a variety of functions in planning, developing, and upgrading high-technology programs. Activities aided by the advisory committees involved in the case studies included the following:

- Identifying the content and scope of emerging or changing occupations and determining the competencies and standards required
- Determining the content and sequence of required courses
- Determining whether a new program area or supplemental courses are the more appropriate response
- Validating and/or upgrading extant courses and developing new ones
- Finding funding, equipment, and facilities for new programs or courses
- Finding qualified instructors and/or ways to upgrade extant instructors
- Helping schools gain programmatic approval by identifying current and future job demand levels
- Devising linkages with companies to provide opportunities for practical (co-op) educational experiences for teachers and/or students
- Participating in workshops, seminars, and other informational exchange activities to aid in technology transfer and in programmatic upgrading efforts

Another planning and development approach used by some of the case studies was for the schools to provide "release time" for some faculty to enable them to develop new program areas, in collaboration with the advisory committees and participating companies, or to upgrade their own skills and knowledge in the technological areas. Release time generally involved providing funding for a substitute instructor, thus freeing the original instructor to pursue program development or skill upgrading. Both Piedmont Tech and Portland Community College used this approach.

Funding, Equipment, and Facilities

The availability of funds to support program development and provide equipment and facilities was inevitably a problem affecting the speed and quality of programmatic responses. In South Carolina, substantial funding for the establishment of Piedmont's Robotics Resource Center came from the state's TEC System. Portland Community College got its funding through normal channels, following state approval of its two proposed new program areas. Milwaukee Tech developed its computer graphics program with funds from the National Science Foundation. Franklin Institute and Tufts-New England Medical Center shared the costs of developing the Medical Electronics Technology Program. DEC's Minicomputer Technology Program was developed by the company and required little alteration to be implemented at Franklin, so its development and start-up costs were minimal to the school.

Finding up-to-date equipment and facilities was a frequent problem in starting up new programs, especially in high-technology areas, where equipment tends to be expensive and often becomes obsolete quickly. Most of the case study programs depended on gifts or "allowances" of equipment from collaborating companies. For example, Milacron provided a T3 robot and other equipment to Piedmont, Computervision provided equipment for Milwaukee Tech, and DEC gave computers and other digital equipment to Franklin. In one case, in the Tufts/Franklin program, equipment, facilities, and instructors were shared in a closely knit instructional collaboration that went considerably beyond the scope of most other company/school arrangements.

Instructional Staff

The problems of recruiting or upgrading instructors for the new programs stem from several factors. A major one has been the scarcity of experienced instructors (especially those with practical, hands-on experiences) in emerging or changing technologies, where few experts exist. Another has been the fact that most potential instructors are lured away from teaching positions by more lucrative careers in business and industry. Salaries in the private sector are reported to be often $10,000 or more per year above school instructors' salaries.

Collaborative arrangements between the schools and companies have resolved some of the problems. In some cases (as with Tufts/Franklin and Allen Bradley/Milwaukee Tech), experienced employees from the companies were "lent" to the schools to teach courses or workshops, and in the case of Tufts/Franklin, instructional responsibilities were divided between Tufts and Franklin according to areas of expertise (i.e., Franklin faculty teaches the electronics background courses, Tufts staff teaches human physiology and practical applications of medical electronic equipment). Having high quality instructors who are simultaneously practicing employees has been an important factor in the success of the programs.

A collaborative solution to the problems of upgrading teachers in changing technologies has been companies' provision of inservice training, by their own experienced staff, to school instructors. Cincinnati Milacron, Tufts–New England Medical Center, and Digital Equipment have all sent experts in the appropriate technologies to their collaborating schools to help upgrade the faculty. Milacron, DEC, and Allen Bradley have also provided training for school instructors at work sites (either during teachers' "release" time or during summer breaks) where the teachers gain practical hands-on experience with the technology and equipment. Finally, some companies have provided funds for instructors from collaborating schools to attend outside workshops, seminars, and professional conferences in the technological areas of mutual interest.

Curricula

Advisory committees encountered in all of the case studies worked closely with school planners to help decide just what form new instruction in high-technology areas should take. In only one case (Piedmont's robotics program) has an entirely new program been deemed the most appropriate immediate response. In other cases, a new program was built by revising some extant courses and adding a number of new ones. This was the approach used by Portland, and by Franklin with both its Medical Electronics Technology Program and its version of DEC's Minicomputer Technology Program. At Milwaukee Tech, the computer graphics courses were created to supplement programs in eleven occupational areas.

Programs tend to be one- or two-year degree-granting curricula, though both Portland and Milwaukee Tech offer the courses individually to provide skills upgrading for incumbent workers in related fields. The schools also offer evening courses, summer courses, workshops, and seminars to give wider access to the public. Piedmont plans similar course and workshop offerings for both instructors and students once its program is underway.

For most of the high-technology programs, which are preparing students for technician-level jobs, hands-on experience is already used or is planned to become a major part of the curriculum. The most potent example of this approach is the Tufts/Franklin program in medical electronics, where the hands-on learning takes place at an actual work site, and where what is learned includes not only planned, constantly updated practical experiences, but the kinds of unplanned experiences encountered in a working hospital environment. The value of the Tufts/Franklin program is further enhanced by its individualized "internship" at the hospital, where every student is assigned a hospital technician to serve as the student's role model. These factors enable graduates of the program to adapt quickly and effectively to the real work environment and to understand its structure and rules.

The need for continual updating of curricula is critical in advanced technology areas, and the case studies have met the need through a variety of strategies. The cooperative training experiences at Tufts/Franklin are automatically updated at the hospital site, where new equipment and techniques are constantly coming into use. In the case of the DEC/Franklin computer servicing program, DEC itself annually reviews the program content at the school and makes recommendations for revisions to the school's advisory panel. At most of the schools, the advisory committees have the major responsibility of reviewing programs and recommending revisions to update them. Milwaukee Tech, Portland, and Piedmont (in planning) also rely on their relationships with professional/technological-interest associations, such as Partners in Progress, the Institute of Certified Records Managers, and the Robot Institute of America.

Program Approval

A condition that can hamper rapid response on the part of publicly funded postsecondary schools is the existence of state department approval procedures and funding patterns that require occupational demand statistics to justify the need for the new program. If a school tries to create a training program early, anticipating the demand for trained technicians in a technology that is just emerging or being adopted in business/industry, the labor market data may be insufficient—or nonexistent—for program approval. If a school delays, its eventual response may delay local companies from adopting new technology crucial to higher productivity. Delays in school response may force some companies to develop their own training programs, which can result in drawing away potential instructors (and students) from public institutions.

Obtaining state approval was not a problem, of course, for a private school like Franklin, and Piedmont's robotics program was mandated by a state agency, but both Portland and Milwaukee Tech had to deal with the problem. In the case of Milwaukee Tech, it was decided that the creation of a new program area should be avoided, at least for the time being; instead, supplemental courses in computer graphics were developed as add-ons for students pursuing study in other, related program areas. Portland, on the other hand, encountered serious problems in validating the demand for trained records management and word processing technicians, due partly to the recentness of local companies' adoption of the related technologies, and partly to a snafu with job titles recorded in the *Dictionary of Occupational Titles* used by Oregon's Division of Employment Statistics. Only with the aid of the companies participating on Portland's advisory committee was the school able to collect job-demand data and validate the need for the programs.

Technology Transfer

Two of the case study schools, Piedmont and Milwaukee Tech, have been in positions of creating training programs for technologies that are advancing so rapidly that even the companies manufacturing and using the technologies are having to scramble to keep abreast of the developments. To meet their needs for current and continuing information, the schools have created organizations that bring together experts from industry, universities, postsecondary vocational schools, and professional associations. Piedmont is creating a Robotics Resource Center, and Milwaukee has created the Partners in Progress organization as an informational feedback organ for computer graphics technology.

These organizations are intended to serve, in part, as technology transfer agents. In the case of Partners in Progress, information sharing is a primary objective, with its Advanced Technology Council additionally funding advanced technological research projects for mutual benefit. An offshoot of the Partners for Progress association was that the National Computer Graphics Association established its Wisconsin chapter headquarters at Milwaukee Tech, which will make seminars and workshops in computer graphics available to Milwaukee Tech students, faculty, and Partners in Progress members.

Piedmont's Robotics Resource Center has technology transfer as one of its major objectives, an intrinsic one in South Carolina's "Design for the Eighties" economic development program. The Resource Center will train instructors as well as students, and there are plans to outfit a truck-van with robots in order to conduct demonstrations of robotics technology at manufacturing companies around the state. The intention is to help transfer the robotics technology to new work sites, thus improving productivity and creating new jobs for robotics technicians.

Providing or creating jobs for graduates of the high-technology programs was a characteristic of every one of the companies that became involved in program planning and development with the post-secondary schools. Technology transfer was specifically among Allen Bradley's desired outcomes in hiring program graduates. Ways of increasing the rate of the transfer of the new computer graphics technology into its company were not only to hire graduates from Milwaukee Tech who had taken the computer graphics courses, but also to underwrite the costs of employee attendance at the evening courses.

PART II

Responses to Changing Technology

PRECISION OPTICS PROGRAM

North Lake College; Irving, Texas

North Lake College is one of the newer members of the Dallas County Community College District, a consortium of seven community colleges located throughout Dallas County. The average age of North Lake's approximately nine thousand students is twenty-nine, although the majority of credit-taking students are between the ages of eighteen and twenty-two. Of the college's 285 faculty members, 65 are full-time, 100 are part-time, and 120 are in the Community Service Program.

North Lake offers a four-semester associate degree program in precision optics. In this program, students learn how to fabricate lenses for a forward-looking infrared (FLIR) system used in weapons guidance, tank fire control, and airborne targeting. The FLIR system is manufactured by Texas Instruments Corporation in Dallas, Texas.

A minimum of sixty credit hours is required to earn the associate degree. The program is designed to accelerate the progression of the student from entry-level to skilled optical fabricator through a combination of classroom instruction and on-the-job training. Applicants for the program are initially either Texas Instruments (TI) employees or individuals recruited by TI at the company's Job Grade 2. Upon successful completion of the first academic training period of ten weeks, students are automatically promoted by TI to Job Grade 7 and assigned to a shift at the company's plant for on-the-job training and evening classroom instruction at North Lake. Students generally require 2.5 years to complete the program, resulting in a skill level equal to that normally acquired after four to seven years of on-the-job training.

Initial development of the Precision Optics Program at North Lake College began in January 1979. In planning and initiating the program, several problems were encountered. One was difficulty in obtaining qualified students. Texas Instruments personnel interviewed four individuals for each student admitted to the program. Another problem was that there was no existing curriculum to meet the specific training requirements of TI's precision optics system. To meet these requirements, some components of the optical technology program at TI's Colorado Springs facility were adopted, and the remainder had to be developed at North Lake College by the TI education coordinator.

The availability of a qualified instructor to each precision optics courses was also a problem. Texas Instruments provided an individual who, although experienced in precision optics, had little or no teaching experience in the classroom. Training for the teacher in the develo ment of lesson plans, use of instructional media, evaluation of students, and other instructional procedures had to be worked out on a trial-and-error basis during initial phases of the program.

The Precision Optics Program was initiated by TI and developed in conjunction with North Lake College within a three-month period—a relatively short time compared to the one-year period required for new program development. Start-up of the program was facilitated by the recruitment of students, an instructor, and equipment by TI. The equipment is mostly power-driven machinery for fabricating lens systems and some measurement hand tools.

Although the program was initiated and is largely operated by TI, North Lake College anticipates a more active role in program operations through provision of its own instructor and open public enrollment in 1982. Currently, the College provides a classroom on its campus and offers instructional advice as needed. In 1982, the equipment currently loaned by TI will become the property of North Lake College. The college administration is optimistic that graduates of the program after 1982 will have placement opportunities with two or three other companies using precision optics fabrication technology in the Dallas area.

Texas Instruments is pleased with the calibre of individuals trained at North Lake. Ten weeks of training in the Precision Optics Program is purported by TI's program coordinator to be equivalent to two to three years' experience on the job. In addition, workers trained at North Lake College are viewed by TI as having a better understanding of performance, quality, and cost factors associated with their jobs.

MICROELECTRONICS PROCESSING TECHNICIAN PROGRAM

Durham Technical Institute; Durham, North Carolina

Durham Technical Institute began in 1948, when a program of Practical Nursing was established under the Vocational and Adult Education Department of Durham City Schools. The school became one of several Industrial Education Centers in 1961 and continued as such, with ever-expanding curricula, until the name was officially changed in 1965 to Durham Technical Institute. The Institute, a charter member of the North Carolina Department of Community Colleges, currently serves thirty-six hundred students through twenty-five technical training programs.

As part of the North Carolina Community College program to support the growth of microelectronics industries in the state, Durham Tech began in 1980 to develop its capability to provide specialized occupational training for microelectronics technicians and process operators. The impetus to develop specialized, company-specific microelectronics courses was due to the construction of the General Electric (GE) Company's Microelectronics Facility in the Durham area.

Representatives of GE met with Durham Tech faculty in December 1979 and indicated that GE would need electronics technicians who could perform equipment maintenance and processing (manufacturing) jobs. The electronics engineering program at Durham Tech was reviewed by the GE representatives and judged to be appropriate for preparing equipment maintenance technicians. The program was considered sufficient to provide essential background training for microprocessing technicians, but several additional specialized training courses in integrated circuit production, testing, and quality control procedures were also needed.

Following subsequent meetings with GE, it was decided by Durham Tech personnel that several credit-granting courses would be developed and offered as one additional quarter of specialized training in microelectronics processing technology. The course would be open to any graduate of an accredited two-year electrical engineering technology degree program. Durham Tech would have sole authority to screen and accept applicants. This is an unusual arrangement for such company-specific training programs, in that employers normally have considerable influence in deciding who is admitted into such a training program. While GE is not obligated to hire persons completing the special courses, GE does consider Durham Tech as its primary source of technicians for job openings.

The president of Durham Tech hired an electrical engineer to develop the content for the new courses and serve as the principal instructor. Arrangements were made between Durham Tech and the Department of Electrical Engineering at Duke University for the newly hired instructor to spend several months at Duke, gaining first-hand experience in its semiconductor processing laboratory.

In order to expand their understanding of the type of training that should be offered and the kinds of equipment necessary for the training, the president of Durham Tech and the new microelectronics instructor visited Foothills College and several microelectronics firms in California in April 1981. During their visit to one of the firms in the Santa Clara "Silicon Valley," they were advised by a company vice-president of a "reverse engineering" instructional approach that coul used to provide students with an in-depth understanding of how integrated circuits are manufactured, without substantial investment in expensive fabrication equipment and facilities for instruction. This approach, which amounts to "dissecting" a silicon chip, layer by layer, rather than constructing a chip from the core out, gives important, first-hand experience in all phases of integrated circuit design and construction. This approach will be adopted as the basis for the equipment-related training course.

In the spring of 1981, two sections of a new three-credit course, Introduction to Semiconductor Processing and Microelectronics, were offered at Durham Tech. A total of one hundred students were registered for the course, which focused on fundamentals of microelectronics but did not provide laboratory experience because necessary equipment had not yet been acquired.

Probably the major problem Durham Tech has encountered in developing the microelectronics courses has been acquiring needed laboratory equipment. Representatives from GE in Durham offered some equipment from a recently purchased GE subsidiary in California, but the transfer of equipment had not been accomplished by the fall of 1981. The State Department of Community Colleges agreed to provide funds for equipment that could not be obtained through other sources. Until equipment from GE has been received, however, the state funds will not be available. Because the state is also currently developing the Microelectronics Center of North Carolina at Research Triangle Park, there is considerable competition for microelectronics equipment and program development funding. The problem is exacerbated by the scarcity and high cost of integrated circuit processing equipment and the desire of the local universities to obtain any surplus equipment for their own programs.

Even if equipment were purchased by the state for use at Durham Tech, the funds would come from "New Industries Training" appropriations, which stipulate that such equipment will not become the permanent property of the school and could be transferred in the future to another school. This situation could jeopardize Durham Tech's long-range goal of establishing a permanent program and facility to provide training for other microelectronics industries that may locate in its region. The president of Durham Tech is seeking to have state-purchased equipment become the property of the school in order to ensure the continuation of the training courses currently being established.

Durham Tech has employed several successful strategies in responding to GE's specific training needs and to developments in the broader field of microelectronics technology. The school hired an instructor with appropriate background and provided her with state-of-the-art, hands-on experiences in Duke University's semiconductor processing laboratory. Visits to existing programs and related industries provided opportunities to learn about relevant curriculum and equipment requirements. An instructional approach ("reverse engineering") was identified that will provide necessary student learning experiences with a minimum of equipment expenditures. (Even with a minimum amount of equipment, expenditures are expected to be around fifty-three thousand dollars.) Response time was shortened by deciding to offer several additional courses to graduates of an existing program, rather than develop an entirely new program. Acquiring needed equipment has been the major difficulty in developing the courses, but the president and staff of Durham Tech and GE are continuing in their efforts to resolve the problem.

ROBOTICS PROGRAM

Macomb County Community College (MCCC); Warren, Michigan

Macomb County Community College (MCCC) is a comprehensive, two-year postsecondary college located approximately ten miles north of Detroit. MCCC comprises a two-campus complex of classrooms and laboratories with an enrollment of thirty-three thousand students, a full-time faculty of approximately three hundred forty-five, and almost five hundred part-time and adjunct faculty. The college offers associate degree programs in arts, applied science, and general studies. It also awards certificates in career curricula, general studies, and behavioral sciences. Many MCCC students can choose a cooperative education option if they are enrolled in the business, office, general education, or industrial curricula.

MCCC offers its students three curriculum plans in robotics. Plan A is for individuals who have an associate degree or bachelor of science degree in related fields, have four years of industrial experience, or have prerequisite courses. These individuals may be granted advanced placement in a two-semester twenty-five credit-hour curriculum. Completion of this program earns students a certificate of orientation to robotics.

Plan B is for individuals who have had the prerequisite courses, training, or related experience to benefit from a six-semester, fifty-one credit-hour program with an emphasis on basic electronics, hydraulics, pneumatics, controls, circuitry, automatic lubrication systems, and mechanical drives and linkages. Students who compelte this program receive a certificate in robotics from MCCC and an acknowledgement from the Society of Manufacturing Engineers (SME) that they have completed the course in robotics technology.

Plan C students are those with no industrial experience who are entering the job market for the first time. These individuals matriculate into the college's Industrial Cooperative Education Experience Program, and complete a two-year curriculum (three years with co-op time) for an associate degree. They are also certified by the American Welding Society for welding and by SME for basic fluid power and robotics technology.

Planning for the robotics program began early in 1978, a time when industrial robots were just appearing in the highly industrialized area a few miles from the college. Development of the program was funded by matching school and state funds. The robotics program was approved by the MCCC Board of Trustees in the spring of 1980, and by the summer of the same year, the first class of students was enrolled and attending classes.

Initially, the robotics program was heavily dependent upon industrial cooperation. Students gained hands-on experience by traveling to companies such as F. Joseph Lamb, Unimation Inc., Auto-place, and Pick-O-Matic. Since that time, however, MCCC has purchased more than two hundred thousand dollars' worth of equipment, and students now have greater access to hands-on assignments and practice at the school. The program now has three robots in the MCCC robotics lab: an Auto-Place robot, a Seiko robot, and the more sophisticated Unimate 2000. With these models, students learn to install, program, and maintain the basic types of robots.

The robotics laboratory is tied into other MCCC laboratories as part of the program's objective to provide hands-on experience in related technologies. One of these is the metrology laboratory, where robotics students learn to qualify the robots, off-line, in terms of resolution, repeatability, and accuracy. These procedures allow students to determine, before actual plant operation, whether their programs for a robot will work exactly as they designed them. Robotics students also have access to the design department's computer graphics laboratory, where they learn to design hydraulic circuits and automated transfer line units, and to program robots off-line.

Major responsibility for the program is shared by two full-time staff persons. The program also employs a number of other part-time instructors, who are recruited primarily from industry.

In addition to the program's three robots, plans are being made to obtain other machines of various capabilities to expand the range of hands-on experience for students. Arrangements are underway to obtain some new robots as donations from local industry. The program's advisory committee is hoping to obtain others through a lend-lease arrangement. This arrangement is viewed as one of the best program strategies, since it allows the program to keep up with the latest equipment in use in industry, as technological innovations are made and higher levels of performance are reached.

Of the first class of twenty-three students who graduated with an associate degree in robotics technology in 1981, eighteen of them, including seven women, were hired within their specialty. With new facilities, which will double the program's space early in 1982, the program will be able to graduate one hundred fifty to two hundred students per year. Four hundred potential students were turned away in 1980 after the program was filled.

LASER/OPTICS TECHNOLOGY PROGRAM

Cincinnati Technical College (CTC); Cincinnati, Ohio

The Cincinnati Board of Education established the Cincinnati Cooperat. School of Technology as a two-year institute for high school graduates in 1966. Since all technical education programs in Ohio were to come under the authority of the Ohio Board of Regents, the Cincinnati Board of Education proposed in April 1969 that the Regents establish a Cincinnati Technical Institute District and approve the Cincinnati Cooperative School as the nucleus to serve that district. The proposal was approved in May 1969, and subsequent actions by the Board of Regents resulted in the school's becoming an autonomous institution later that year.

In 1972, the name of the Institute was changed to Cincinnati Technical College (CTC). Currently, CTC has thirty-nine hundred students enrolled in fifty degree and certificate programs, with 220 full-time plus 100 part-time instructors. The number of co-op employers has increased from 37 in 1966-67 to 500 in 1980-81.

The school's co-op education plan is a key component of many of its technical programs. This plan combines solid academic and technical education with alternating terms of work experience and results in 90 percent of the graduates' completing their education through a co-op plan.

Among the many technology programs offered by CTC, the Laser/Optics Technology Program, begun in 1976, is one of the newest. The program, offered through the Physical Science and Mathematics Division, is the first and only one in Ohio, and one of the few programs in the country designed to train students to meet the growing industrial need for laser/optics technicians. Such technicians must have knowledge of the theory of electro-optic system operations, as well as practical, hands-on experience, and should have the ability to apply their knowledge of electro-optics to the product area of the employer.

The impetus to begin a laser program came from the dean of the Physical Science and Mathematics Division of CTC, who had been following the growth of industrial laser/optics applications since his early days as a student of physics. He learned of a laser employment-needs survey that was conducted, prior to 1976, by a scientist–instructor at the University of Cincinnati. The survey results suggested that the local need for laser technicians warranted the development of a program at CTC. The dean persuaded the instructor to leave the University of Cincinnati and join the faculty of CTC to start a new program in laser/optics.

The first step prior to developing the new program was to update the original needs survey. New data, which confirmed the need for laser/optics technicians and the willingness of local industries to support a program by providing co-op training in their establishments, were collected. The second step was to submit a proposal to develop the new program to the Board of Regents, who subsequently approved the project.

An early problem in planning the curriculum was the translation of theoretical information about lasers into an appropriate level of content for educating technicians. The problem was solved when the CTC instructor discovered the availability of laser program guidelines and content materials from the Technical Education Research Center (TERC). The TERC guidelines were modified with the assistance of a representative from a similar TERC-guided laser program in Texas.

An advisory committee of representatives from major industries in the area had been established early in the planning phase of the program. Committee members served as reviewers for the initial curriculum plan and provided valuable information about what technicians should know and be able to do in the respective companies. Based on the committee's advice, the TERC curriculum was revised and the full curriculum plan was finalized. The committee members were also instrumental in locating and securing arrangements for student co-op work-experience openings with local companies.

The final curriculum plan included five new laser/optics courses and other appropriate courses in mathematics, electronics, physics, human relations, communications, computer language, and economics, as well as the cooperative employment experience. The entire development process took about ninety days to complete. Students were first enrolled in the program in 1978, and the first seven graduates completed the program in 1980. All of the graduates were hired in their field. Eleven additional graduates completed the program in 1981, nine of whom found employment in their field and two of whom chose to pursue other activities.

Through its rigorous course of study and lab experience, the Laser/Optics Program provides students with in-depth education and training experiences in the scientific and technical aspects of how laser/optics systems work, why they work, and how to direct and control the laser beam. Because of the lack of more powerful laser equipment, the program must teach certain target effects and control functions through simulations. Graduates do receive strong science and math preparation, which qualifies them for a variety of high-level technical occupations related to laser/electro-optics systems.

Although the program has been operating successfully, there are several problems remaining. Because of reductions in state funds for higher education, the program has not received the level of funding originally anticipated and necessary to purchase all of the equipment desired. Currently, the laser lab has about seventy thousand dollars' worth of equipment, including several five-watt lasers and a twenty-watt laser, which is the largest in the lab but is not powerful enough to conduct actual cutting, welding, or drilling operations. The desired laser should have 400 watts of power and would cost around $150,000. A current student project is underway to build a carbon dioxide gas laser at the approximate cost of six hundred dollars, compared to an average purchase price of fifteen thousand dollars for a manufactured unit. When operational, the carbon dioxide gas laser will be used to supplement the lab equipment.

The program's instructor and the dean of the division have not had success in securing grants for the purpose of purchasing equipment through the National Science Foundation (NSF). They have submitted several grant applications and made several contacts with NSF officials to obtain directions and information about appropriate grant program specifications and procedures. Their requests (to date) have been turned down, although NSF reportedly is funding similar programs in four-year postsecondary institutions. Cincinnati Tech's efforts to obtain equipment from federal government surplus equipment depots in Columbus and Cleveland resulted in further frustration, when CTC faculty were informed that they could not obtain surplus equipment without an NSF grant number.

Another problem that faculty and students have encountered has been the shortage of cooperative work experience openings in local industries. The school classifies co-op openings according to how closely related they are to the field of study. The categories are "directly related," "indirectly related," and "not related." The laser/optics students are not placed in openings "not related" to their field. The initial seven graduates of the program, when hired, filled the co-op slots that had been available to them. Elimination of other co-op slots has been due, in part, to the general economic slowdown, which has forced many industries to delay their plans for introducing laser systems in their plants. Local openings in electronics companies in the area have provided "indirectly related" co-op positions for laser/optics students, but because of a dramatic increase in CTC's Electronics Program enrollment in 1979, the number of openings available for laser/optics students in 1980–81 was greatly reduced.

Currently, the program has been able to place half of the laser/optics students in "related" or "indirectly related" co-op openings.

The demand for laser technicians has slowed along with the economy, but the long-range employment prospects for laser/optics graduates are good. Cincinnati Technical Institute faculty expect the program to reach its initial growth projections by 1984 or 1985.

MICROELECTRONICS RESOURCE CENTER

Tri-County Technical College; Pendleton, South Carolina

A more serious problem facing two-year technical college programs in electronics is keeping pace with the rapid innovations in the field of microelectronics. Tri-County Technical College has come up with several strategies to maintain a program that reflects state-of-the-art technology.

Tri-County Technical College is one of sixteen two-year technical colleges in South Carolina's Technical Education College System (TEC). TEC's mission is to aid economic development and job creation in the state by training people for new jobs. Recognizing the rapid changes in technologies used by businesses and industries, the leaders of TEC developed the "Design for the Eighties," an ambitious program to meet the expected needs of South Carolina industries during the next five years.

Tri-County College was selected to be part of the "Design for the Eighties" program. The challenge accepted by Tri-County was to develop, within one year, a Microelectronics Resource Center that would keep all sixteen technical colleges in TEC, as well as South Carolina industries (both current and new), at the technological "cutting edge" of microelectronics. Through its training and demonstration activities, the Center is to facilitate the transfer of microelectronics technology to local businesses and industries, to help create new jobs, and to boost economic development in the state by training technicians for new businesses and industries that are expected to be attracted into the state by the availability of a trained technical work force.

The dean of instruction and the engineering technology faculty at Tri-County established three objectives for meeting the challenge: (1) to assess the state-of-the-art and future trends in microelectronics, (2) to identify and recruit a recognized expert in the field to direct the Resource Center, and (3) to develop a curriculum plan to meet the training requirements for microelectronics technician-level occupations in South Carolina.

To meet the first objective, a faculty team from Tri-County travelled to California's "Silicon Valley," where the members visited Foothill, San Mateo, Mission, and De Anza technical or community colleges to learn about the microelectronics programs in those schools. They also attended a conference of the American Society for Engineering Education and toured Intel and Hewlett-Packard Corporation facilities. During a visit to the IBM Training Center in Atlanta, it was suggested that Tri-County's Microelectronics Resource Center adopt a "fast-follow" approach to keeping pace with technological changes. Personnel at IBM expressed the opinion that industry generally does not expect technical school programs to be product-specific in their training. They also suggested that the Resource Center training program strive for no more than a two-year lag behind the most current innovations in the field—that is, the program should "follow fast" on the heels of new technology.

Armed with the information gained from their visits to the school programs, conferences, and corporation sites, the Tri-County faculty team initiated a national search for a director who could bring leadership and expert knowledge to the Resource Center. The search identified and successfully recruited an individual with appropriate engineering technology qualifications and experience. The new director joined the Tri-County faculty in the fall of 1981.

Efforts to develop a curriculum plan appropriate to a fast-follow approach in microelectronics came to fruition with the completion of a DACUM* planning session held in the summer of 1981. Representatives of IBM, Texas Instruments, Xerox, and National Cash Register participated in the DACUM process, along with other consultants and technical experts. The outcome of the planning session was a matrix of competencies for various microelectronics-technician jobs.

In addition to the DACUM panel, a peer advisory committee, consisting of representatives from educational institutions and industries in South Carolina, was established. The committee will meet three to four times a year to deal with needs assessments, staff development, equipment, and curriculum concerns. A national advisory committee, composed of representatives from leading high-technology and microelectronics industries around the country, has also been established. The national committee will provide information on current and future trends in the field and will aid in keeping the Microelectronics Resource Center's program at or near the leading edge of the technology.

Renovation of an existing laboratory at Tri-County was begun in the summer of 1981, with the facility scheduled for use as part of the Microelectronics Center in the fall of 1981. An inventory of needed equipment and a floor and work-station plan were also developed for the facility. Equipment purchases are scheduled to proceed as the "Design for the Eighteis" appropriation of $104,000 is made available. Tri-County has also received $32,000 from "Design for the Eighties" to support one full year of release time for a faculty member to coordinate the initial program planning and development activities. The total planning and development effort has taken about nine months to complete.

When fully operational, the Microelectronics Resource Center, in addition to training students, will serve the faculty in the other TEC system schools by conducting inservice training sessions and by assisting the other schools in updating their microelectronics-related curricula. The Center will also serve business and industry in South Carolina by providing educational and training courses, seminars, and workshops to assist employees of the companies in keeping up with changes in microelectronics technology as they occur.

The Tri-County initiative represents a combination of approaches and techniques designed to establish a centralized facility and staff capable of quickly and steadily infusing new microelectronics technology into the TEC system and South Carolina's industries. The project has capitalized on both regional and national experts to develop a state-of-the-art curriculum plan and model facility. Through the judicious selection of modern and flexible equipment, the Center will be able to incorporate innovations and closely follow future changes in microelectronics. An advisory committee composed of representatives from leading national corporations will continue to provide information on future trends to guide the Resource Center's growth and direction. The most unique feature of the Resource Center is its systematic plan to help the faculty of other schools stay up-to-date in the field, and to serve the technological needs of current and future industries in the state.

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*DACUM: A systematic group process using technical experts and (in this case) employers to analyze an occupation and identify relevant job competencies, knowledge, and attitudes to be taught in a course or series of courses.

DISCUSSION

The Case Studies: Problems and Solutions

The five programs, reported here as case studies, represent a variety of approaches that schools are using to develop programs or sequences of courses to meet local and regional job-skill needs in high-technology industries. Information gathered during site visits and through discussions with school personnel has helped identify factors and conditions that constrain or facilitate appropriate educational responses to high technology.

Program Planning and Development

A variety of approaches were used to plan and develop the high-technology programs at the schools in the case studies. North Lake College's program was essentially planned and developed by Texas Instruments Corporation (TI), and was delivered intact for the fast-start program at North Lake. The college provided technical assistance and classrooms, while TI provided the instructor, curriculum, equipment, and students. Durham Tech, on the other hand, developed two new specialized courses, offering them as supplements to a more traditional associate degree program in electronics that was already in existence at the college.

At Macomb County Community College (MCCC), the program was planned and developed by two faculty members, both of whom had had many years of industrial experience. A unique aspect of MCCC's robotics program is that robot use was not already well established in American industry at the time the program for robotics technicians was being planned. In effect, MCCC's program was in the forefront of the demand for trained technicians and has, therefore, been able to provide workers to assist in the introduction of the new technology into a variety of local industries.

Cincinnati Technical College created a full two-year program by developing five new courses in laser/optics technology and, by combining those with courses from existing programs, now provides a broad spectrum of laser/optics applications training. Tri-County Technical College established a set of competencies identified by a panel of experts through the DACUM process. Tri-County planners combined the competencies list with information gleaned from industry and school site visits to create a series of learning experiences that could be delivered through the school's Resource Center training facilities.

Funding, Equipment, and Facilities

At North Lake College, Texas Instruments provided equipment that is to become the property of North Lake in 1982. At that time, North Lake will begin to provide a full-time instructor, though the details of the arrangement remain to be determined. The program, while conducted at the North Lake classrooms, continues to be funded by TI.

At Durham Tech, funds for equipment have been appropriated through North Carolina's Industry Training Program in order to supplement anticipated donations of equipment from General Electric. Problems with acquiring the promised equipment from GE have delayed the state funding; however, it is uncertain just when and how much equipment will actually become available to the college, especially since state funding depends on the acquisition of the GE equipment.

Macomb County's program is funded at the 50 percent level by the state, and the other 50 percent of funding is matching funds provided from the school's own budget. In the beginning the program depended heavily on industry for the use of equipment (i.e., students gained hands-on experience by traveling to local companies for cooperative, after-hours training on the companies' robots). Since that time, the college has pruchased three robots, and plans to acquire more robots through donations and loans from industry. The program is housed in the classrooms and laboratories at MCCC.

At Cincinnati Tech, support for the laser/optics program came through traditional funding channels, based on full-time equivalency (FTE) reimbursement. However, the program has been subject to reductions in state funding for all higher education programs. The school has not been able to obtain grants from the National Science Foundation for equipment, possibly because NSF gives higher priority to funding four-year rather than two-year programs. Some equipment has been purchased through state funding, but it is insufficient for certain vital areas of laser/optics training. A unique partial solution is that students are constructing a carbon dioxide gas laser as part of their instruction; the completed laser will become part of the program's lab equipment.

Equipment and renovated facilities for Tri-County's program have been funded both by college resources and by special state funds provided by the "Design for the Eighties" program.

Instructional Staff

The instructor for the North Lake program is provided by Texas Instruments, although the college expects to provide its own instructor on a full-time basis beginning in 1982. Whether this will happen or not is unclear, however, since a fluctuation has developed in the need for technicians at TI.

At Durham Tech, the instructor for the microelectronics program was hired from private industry. This individual, who holds an electrical engineering degree, was provided with inservice experience with microelectronics processing equipment through Duke University's seminconductor laboratory facilities.

Major responsibility for Macomb County's program is shared by two full-time instructors. Instructors from other technical areas are also involved in the program, generally in focusing the use of robotics in their areas of specialization (e.g., drafting, computer graphics, metrology, and so forth).

The instructor for the core courses in laser/optics at Cincinnati Tech has a Ph.D. in solid-state physics and had conducted research in laser applications prior to joining the CTC faculty. The instructor assisted in developing the new courses, in addition to teaching them.

At Tri-County, existing faculty are continuing to learn about new technology while teaching existing courses; at the same time, a recognized expert in electronics has been recruited to direct the Microelectronics Resource Center and to conduct its new training activities there.

Curricula

At North Lake College, the precision optics curriculum was developed by Texas Instruments at its own Colorado Springs facility and was modified by TI in Dallas to meet the specific training needs for the North Lake program.

At Durham Tech, a number of specific course development tactics were used, including the use of limited site visits to related programs, recruitment of an individual from industry to develop and teach the microelectronics courses, provision of inservice experiences for the instructor at a university laboratory facility, and development of a reverse-engineering approach of instruction to minimize equipment requirements.

Macomb County's robotics program provides a flexible curricular approach with three options for students. Plan A allows those with an associate degree or bachelor's degree in related fields to get a certificate of orientation to robotics. Plan B is for those with experience in the skilled trades and allows them to get a certificate in robotics and acknowledgement from the Society of Manufacturing Engineers. Plan C is for those entering the job market, and enables participants to get an associate degree in robotics.

Development of the laser/optics curriculum at Cincinnati Tech was based on guidelines and materials already available from the Technical Education Research Center (TERC). An advisory panel reviewed the TERC materials for Cincinnati Tech, and the panel's recommendations were used to modify the TERC materials to reflect the performance requirements of local industries. Assistance in this task was provided by a consultant from a program in laser/optics already in existence elsewhere. The entire curriculum development process took about ninety days to complete.

Strategies for developing the curriculum at Tri-County included making site visits to extant related programs, attending electronics conferences, visiting leading electronics industries and their training centers, recruiting an expert to develop and direct Tri-County's program, and using a DACUM process with a panel of technical experts to develop competency lists for microelectronics technicians. The effort took around nine months to complete, including developing plans for equipment selection and the layout of lab facilities.

Program Approval

Program approval followed typical channels for both Durham Tech and Cincinnati Tech, and no particular problems were encountered. At North Lake, however, the usual approval procedures, which normally take a year, were not followed. North Lake's program was a quick-start program, with all program components except the actual classroom facility already provided by Texas Instruments, so approvals were obtained in only three months.

At Macomb County, the robotics program was one of twenty-three submitted to the Board of Trustees for approval. After a ten-minute presentation to the Board, the robotics program and several others were approved for start-up activities.

Tri-County's Microelectronics Resource Center originated with the South Carolina Technical Education College System, whose Board of Directors approved a Center prior to identifying the specific college that would develop it. Approval of Tri-County as the site of the Resource Center came from South Carolina's leaders in the "Design for the Eighties" program, who selected the colleges for all of the state's new Resource Centers.

Technology Transfer

The various programs have a considerable range of actual or potential effects on the transfer of advanced technology between the schools and the industries involved. In some programs, such as Durham Tech's and Cincinnati Tech's, technology transfer is not an important objective, as the programs are fairly specialized to meet local industry needs. Similarly, at North Lake, the program does not facilitate technology transfer, since its students are Texas Instruments employees, and the technology that is taught is specific to TI's processes and equipment. If North Lake's program becomes open to the public (as is planned for 1982), other companies in the region may eventually benefit from potential technology transfer by hiring North Lake's graduates, though some program expansion and modification would probably be necessary to increase the graduates' employability by other companies.

At Macomb County, on the other hand, the program greatly facilitates technology transfer through its multiplan (Plans A, B, and C) curriculum options. The first two plans serve individuals with related education and/or experience in robotics technology, and the curriculum design is helpful in transferring updated robotics technology and know-how into local industries. Macomb County's robotics program also began before the auto industry became a heavy user of robotics technology; this benefited Macomb County's graduates and the local auto companies, as robotics technology expanded concurrently in the industry. Macomb County graduates were ready to enter robotics technician positions in that industry, facilitating the quick adoption of the technology. The program at Macomb is one of the first fully developed robotics curricula in the United States.

Technology transfer is a primary, conscious objective of the Microelectronics Resource Center at Tri-County Tech. As part of South Carolina's "Design for the Eighties" program, the Resource Center was developed in response to changing technology, as well as in anticipation of projected industry needs for technicians through the 1980s. The Center also will aid in the transfer of microelectronics technology to local businesses and industries through seminars, conferences, workshops, and special courses.

PART III
Recommendations

RECOMMENDATIONS

The recommendations given here have been extrapolated from information collected during site visits, from discussions with educators and industry representatives around the country, and from ideas and suggestions gleaned from reviews of research and literature. The following strategies and approaches are offered with the intention of stimulating leaders in education, business, and industry to cooperate in fostering the growth of high-technology enterprises, and in developing appropriate educational and training programs to prepare technicians to meet labor demands in those crucial technologies.

Recommendations for Two-Year Postsecondary Colleges

- Postsecondary leaders and planners need to maintain their awareness of and sensitivity to changes in advanced and emerging technologies and should closely monitor the immediate and future impact that emerging technologies will have on certain labor-intensive and semiskilled jobs. This can be done by systematically acquiring information from both established and emerging information resources, including journals and publications from technology-related organizations and industries, professional scientific, engineering, and technology research associations, university and government research centers, and representatives of advanced technology manufacturing associations across the country. New programs will have to be designed to emphasize the skills needed in the future, and to de-emphasize those that have become or will soon become obsolete. In some cases, more traditional programs may need to be phased out to free up resources for new, more occupationally relevant programs. For example, the increased use of robots and computer-controlled machine tools and design systems will displace many jobs in production welding, machine tool operation, drafting, painting, inspection, and assembly. Other jobs will require greater fluency in routinely accessing, analyzing, interpreting, and applying computer-based systems.

- Postsecondary planners should adopt a systematic procedure for reviewing the need for new technology programs and base their decisions on the following: actual measures of the rate of substantive change in the particular technology, the pace at which companies are adopting the technology, the existing capacity within the business/industry community and the school itself to collaborate in developing a new program, and the extent to which the new program will support economic growth in the region or contribute to the maintenance of existing industries.

- Postsecondry institutions should establish close linkages with technical and professional societies to exchange information in various technology areas and to collaborate on curriculum development activities.

- Postsecondary institutions should form or join an alliance with other educational institutions for the purposes of sharing the costs of developing new programs and courses in high-technology areas; sharing materials and ideas; exchanging faculty for teaching and inservice activities; identifying and sharing their combined expertise and resources with businesses and industries; and mutually supporting projects in areas of common need.

- Postsecondary institutions can aid in the transfer of new technology by establishing themselves as information links between corporate research and engineering departments, university research centers, and potential users of a technology in the local community. Such linkages would allow the postsecondary schools to transmit advance information about the technology to local businesses and industries by conducting seminars and workshops and by providing consulting services to potential users. Additionally, school personnel could have access to new information and developments, enabling them to stay abreast or ahead of emerging local needs. It should be noted that relationships between education and the private sector must be developed over time and may have to start on a small, even individual, person-to-person scale. Schools that employ the services of people who are knowledgeable about and respected by the business community have been successful in establishing cooperative and supportive relationships with the private sector.

- Postsecondary institutions need to take calculated risks by developing their institutional capabilities in new technology areas as a means of attracting new industry or supporting more rapid adoption of new technologies by existing local businesses and industries.

- Postsecondary schools need to provide release time for faculty members to engage in advance program planning, course development, and inservice training for new technologies.

- Postsecondary schools should seek to develop or expand cooperative training programs in industry sites in order to provide students with access to expensive or exclusive equipment and facilities in high-technology areas.

- Postsecondary institutions should consider setting aside monies in their annual budgets to provide special funding sources to support interim courses in response to unexpected training needs that can arise as new companies move into the community, or as local companies adopt new technologies.

- Postsecondary institutions must establish policies and systems that will allow them to provide appropriate types of training to business and industry when it is needed. The human resource needs of business and industry range from a need for limited job-specific entry-level or upgrading training to the need for a continuous supply of extensively trained technicians for a broad range of occupations. Establishing a procedure for assessing a client's needs, determining the required resources and related costs, and contracting with the client to provide the training in a speedy and businesslike manner can greatly enhance the reputation of the school in the business community and foster greater cooperation with the private sector.

Recommendations for State and Local Agencies and Organizations

- State departments of education, boards of regents, and local school boards need to review their procedures, rules, regulations, and funding mechanisms with the intention of eliminating or streamlining the process of approving and funding new courses or programs in advanced technology areas.

- Boards of regents and state departments of higher education need to establish or strengthen affiliations between postsecondary technical colleges and state universities in order to utilize the university faculties' expertise and aid in developing and teaching advanced-technology courses.

- In the case of new programs that are initially more costly to develop and maintain, state funding agencies should consider providing additional monies during the first and second years, later reducing the funding support as tuition or local support increases.

- State departments of economic development, chambers of commerce, and employer associations should provide assistance to postsecondary institutions in gaining access to, or borrow equipment and materials from, manufacturers and users.

Recommendations for Business and Industry

- As the resources of schools and public funding agencies become more scarce, business and industry will have to share more of the costs of developing and operating new programs in high-technology areas, particularly those in rapidly evolving technologies requiring frequent updating of skills, knowledge, and equipment.

- Industry producers and users of high technology should take advantage of new tax allowances and write-offs by donating or selling equipment at reduced prices to educational institutions.

- Attracting and retaining qualified faculty in advanced technology areas will continue to be a problem for schools. Private companies can assist schools by providing personnel to teach on a part-time basis, by serving as inservice training centers for updating existing school faculty, and by providing as much information as possible as early as possible about future technological changes, job requirements, and training needs. This will help schools by providing adequate lead time for planning and developing new courses and updating current faculty or recruiting new instructors, as necessary.

- Individuals in private business and industry should seek opportunities to serve on advisory committees to provide postsecondary schools with advance planning information and curriculum content recommendations for new programs and courses.

- Business and industry should consider transferring courses they have developed to postsecondary technical colleges as a way of reducing training costs and attracting new employees.

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